

# PATENT SPECIFICATION

(11)

1 248 505

## DRAWINGS ATTACHED

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- (21) Application No. 2768/69 (22) Filed 17 Jan. 1969  
(31) Convention Application No. 6 800 875  
(33) Netherlands (NL)  
(45) Complete Specification published 6 Oct. 1971  
(51) International Classification C 12 c 7/00 7/04  
(52) Index at acceptance  
C6E 11B1 11B2 11C 3



## (54) PRODUCTION OF A WORT CONCENTRATE OR POWDER WITH THE AID OF ENZYME PREPARATIONS

- (71) We, N. V. CHEMISCHE FABRIEK "NAARDEN", a Dutch limited liability company, having its place of business at Naarden, the Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—
- 5 10 15 20 25 30 35 40 45
- The invention relates to the production of a brewers' wort in concentrated or dried form with the aid of enzyme preparations, and to the production of beer, or similar alcoholic beverages, by fermentation of this wort.
- There is a demand in the brewing industry for a process for the manufacture of wort in concentrated form, which is cheap to transport and from which beer can be made when it has been diluted or dissolved.
- Processes are known for the manufacture of an evaporated wort concentrate (see, for example, the Brewers Digest 39 (1964) No. 7, 24, Dutch Patent Application 66,01087, laid open to public inspection, and U.S. Patent Specification 3,290,153). The starting material used in all these processes is malt wort, prepared by conventional means, with a solids content of about 12% by weight.
- The evaporation is carried out in several steps in a vacuum evaporator to avoid any deleterious effects on the colour and quality of the concentrate. These processes are complicated and require extensive apparatus.
- There are some known processes wherein unmalted grain is the main starting material. The grain is subjected to the action of enzymes for the preparation of wort (see Specification No. 977,592). According to Specification Nos. 1,014,114 and 1,083,485, the unmalted grain is subjected to an enzymatic liquefaction process and the resulting product is added to a mash obtained by malting.
- In Specification No. 1,170,836 a process
- is described wherein an extract is prepared from material containing flour, which extract may be used as raw material in the brewing industry. Material containing starch, such as ground grain, is used as starting material and this is made into a mash with water. By the addition of acid, the pH is adjusted to such an extent that peptization occurs and the natural enzymes present in the material are liberated. At a pH of 5.0 to 6.0 an interaction of a proteolytic and an amylolytic enzyme, preferably in this sequence, is brought about, and then the enzymes are inactivated by raising the temperature. After being filtered the extract may be fermented to produce beer in the same way as is usual with wort. Alternatively, the extract may also be made into a concentrate. This known process has some disadvantages. It is known that acid has a deleterious effect on the natural enzymes present in grain, more specifically on the protease. It has not become clear from the abovementioned patent application whether the acid is neutralized afterwards. As the temperature does not rise above 75°C during the mashing process, there is only a limited extraction. In addition to this, there is an insufficient dissolution of the cellulose and the gummy constituents of the grain because the cytolytic enzymes required are not present. This is a disadvantage, because the dissolved cellulose, hemicellulose and gums play an important part in obtaining the desired physical-chemical and organoleptical properties of beer, like foam stability in storage and the so-called "full-bodied" taste.
- A further great disadvantage is that low concentrations are used. The resulting final extract has a solids content of about 20-25% by weight, which cannot be concentrated in one operation in an economically and technically attractive way, and can definitely not be processed into a dry product in one step. The application does not state in which way
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the extract is made into a concentrate. A dry product has great advantages because of its good keeping qualities and because it can be easily and cheaply transported.

- 5 A concentrate may cause difficulties in drawing off and pumping, because its viscosity is high and because it may even crystallize. In none of these known processes, wherein enzymes are being used, have the 10 enzymatic preparations been standardized as to activity, while this is necessary to control the process and to be able to adjust to the proper degree of degradation.

We have now devised a process for producing a brewers' wort which economically produces wort in a concentrated or dried form and accordingly, we provide a process for the manufacture of a brewers' wort in a concentrated or dried form, which comprises 15

20 the steps of:

(a) mixing a finely-divided starch-containing material with water, at a temperature of from 30 to 50°C, to form a mash having a solids contents of from 25 to 50% 25 by weight,

(b) adding cellulase, hemicellulase, protease and  $\alpha$ -amylase to the mash and, if necessary, adjusting the pH of the mash to between 4 and 7,

30 (c) raising the temperature of the mash to from 50 to 60°C so as to degrade and dissolve the cellulose, hemicellulose and proteins in the mash,

(d) further raising the temperature of the 35 mash to from 86 to 88°C so as to liquefy the starch constituents of the mash,

(e) cooling the mash to from 55 to 62°C, adding a saccharifying enzyme, and saccharifying the starch until the ratio of fermentable 40 sugars to non-fermentable polysaccharides in the mash reaches a proportion suitable for the brewers' wort,

(f) raising the temperature of the mash of from 85 to 115°C so as to inactivate the 45 saccharifying enzymes,

(g) filtering the mash, and

(h) concentrating or drying the filtrate.

Because the process of this invention is carried out at higher concentrations than 50 with the known processes, it is much more advantageous from a viewpoint of heat economy.

In this process, grain, such as degerned corn, rye, wheat, rice and particularly barley, or mixtures thereof, is preferably used as the starch-containing material; barley of a quality selected for its good germinating capacity (such as is required in the malting process), is not necessary, and a cheaper 60 quality will suffice. Buckwheat may also be used as the starch-containing material.

As distinct from the known processes, according to the invention a mash is made having a high solids content (from 25 to 65 50% by weight). The pH of this mash is

adjusted to between pH 4 to 7, depending on the optimal pH at which the enzymes added to the mash react. One or more enzyme preparations are then added to the mash, the preparations having standardized cellulase, 70

hemicellulase, protease and  $\alpha$ -amylase activity. Optionally, an enzyme preparation containing pectinase is added to the mash. Thermostable cellulase, hemicellulase, pectinase, and protease preparations are used 75

and those obtained from fungi are suitable. It is particularly desirable to use pectinase when the starch-containing material has a high pectin content. The proteolytic enzyme

may be either vegetable-derived, such as 80 ficin, bromelin or papain, or animal-derived, such as pancreatic protease, or derived from fungi. Protease from the known mutants of the strain *Bacillus subtilis* is very suitable. The thermostability of the  $\alpha$ -amylase used 85

has to meet high demands since it has to display its activity at a temperature of from 86 to 88°C. As this temperature is higher than that at which the other enzymes display 90

their activity, the  $\alpha$ -amylase is simultaneously added to the mash together with the other enzymes for convenience sake. Of course, the  $\alpha$ -amylase does display some activity at the lower temperature level. An  $\alpha$ -amylase meeting the demand required for 95 the invention may be obtained from a highly thermostable mutant of the strain *Bacillus subtilis*.

The mash containing the enzymes is then held at a temperature of from 50 to 60°C, 100 whilst it is stirred to prevent the solid constituents from settling. At this temperature, cellulose, hemicellulose, gums, proteins (and any pectins present) are degraded and dissolved in the mash. After the proteolysis, 105 the filtrate of the mash should have a solids content of 12% by weight and a nitrogen content of at least 700 mg/l and in general the time required for this degradation amounts to from  $\frac{1}{2}$  to 4 hours. 110

The temperature of the mash is then gradually raised to from 86 to 88°C with continued stirring and at this temperature the  $\alpha$ -amylase displays its optimal activity. This enzyme liquefies the starch while forming dextrins, causing it to be more easily saccharified in a later stage of the process. This liquefaction is generally accomplished in from 10 to 60 minutes. Because of the high temperature at which the liquefaction 115 is carried out, a high yield of water-soluble substances is obtained during the subsequent saccharification step, i.e. providing a high extract yield.

After liquefaction, the mash is then cooled 125 to from 55 to 62°C and a saccharifying enzyme added. This may be a malt flour or malt extract, an amylase preparation derived from fungi and/or an amyloglucosidase preparation derived from fungi. The saccharifi- 130

cation, during which, inter alia, maltose is formed, is allowed to continue until the ratio of the fermentable sugars to the non-fermentable polysaccharides has reached the value desired for the brewers' wort. This ratio depends on the kind of beer or other beverage being prepared. As a rule, the degree of fermentation (also known as the apparent attenuation) in manufacturing beer amounts to 75-80% (i.e. the percentage of fermentable sugars). The degree of fermentation should amount to at least 75%. The determination of the degree of fermentation has been described in Analytica EBC (European Brewery Convention), 2nd edition (Elsevier 1963), page 61. The saccharification is allowed to progress to such an extent that the colour reaction of the mash with iodine is negative. The saccharification usually takes from  $\frac{1}{2}$  to 10 hours. If the saccharification progresses too far, the physico-chemical and organoleptic properties of beer

manufactured from the wort are detrimentally affected.

To manufacture products of consistent quality, carefully weighed amounts of enzyme preparations, standardised as to activity are used. Preferably, the degrading enzymes added to the mash in step b) of the process are used in the following doses: 30

cellulase	: 200-600 units
hemicellulase	: 200-1000 units
pectinase	: 500-2000 units
protease	: 50-500 Northrop units
$\alpha$ -amylase	: 175,000-1,000,000 modified Wohlgemuth units

These dosages are with respect to 1 Kg. of solids in the mash. 40

The dosage of the saccharification enzymes added in step e) of the process is preferably as follows:

45	: 10% by weight of the solid starting material in the mash, calculated with a product having a diastase activity of 250 (the diastase activity being calculated according to the Windisch-Kolbach method);
50	amyloglucosidase : 100-300 amyloglucosidase units/kg of solid starting material in the mash.

The activities of the enzymes as referred to herein are defined as follows:

#### Cellulase:

55 Interaction of the enzyme with a solution of 938 mg of carboxymethylcellulose, type "70 C high" from Hercules Inc. U.S.A., in 500 cm<sup>3</sup> of water is brought about at pH 4.4 and at a temperature of 40°C. The changes in viscosity are determined as a function of time in an Ostwald-Cannon-Fenske viscometer.

$$65 \text{ Activity} = \frac{1000(F_{10}-F_5)}{w} \text{ units/g.}$$

w stands for the weighed amount of enzyme in mg and F<sub>10</sub> and F<sub>5</sub> stand for the relative fluidity after 10 and 5 minutes respectively. The relative fluidity F has been defined as

$$F = \frac{T_1-T_w}{T_t-T_w}, \text{ wherein } T_w \text{ stands for the flow rate of water.}$$

75 T<sub>1</sub> stands for the flow rate of the substrate which has not been treated with the enzyme and T<sub>t</sub> stands for the flow rate of the substrate subjected to the action of the enzyme after the action has lasted t 80 minutes, time being measured in seconds.

#### Hemicellulase:

A 0.2% solution of locust bean gum is

subjected to the action of the enzyme at pH 4.5 and at a temperature of 40°C. 85

$$\text{Activity} = \frac{1000(F_{10}-F_5)}{w} \text{ units/g, wherein}$$

w, F<sub>10</sub> and F<sub>5</sub> have the meanings stated above. 90

#### Pectinase:

A polypectin is subjected to the action of the enzyme at pH 4.2 and at a temperature of 30°C. 95

$$\text{Activity} = \frac{33.3(F_{10}-F_5)}{w} \text{ units/g wherein}$$

w, F<sub>10</sub> and F<sub>5</sub> have the meanings stated above. 100

#### Protease:

A casein solution is subjected to the action of the enzyme at pH 7.4 and at a temperature of 40°C for 35 minutes. The casein which has not been degraded by the enzyme is then precipitated at pH 4 and removed by filtering. The amount of dissolved casein in the filtrate is colorimetrically determined at 660 m $\mu$ , after a blue colour has been formed using Folin-Ciocalteu reagent (the latter reagent is described in "Practical Physiological Chemistry" by Hawk, Oser and Sum-

merson, Blakiston Comp., Garden City, New York, 1954).

$$5 \quad \text{Activity} = \frac{F \times A_{660}}{w} \quad \text{Northrop units/g.}$$

wherein  $A_{660}$  stands for the extinction at 660 mu, w stands for the weighed amount of enzyme in mg and F stands for a factor depending on the enzyme, the cell and the type of spectrophotometer. The values of F are for a "Spectronic 20" (Trade Mark) spectrophotometer manufactured by Bausch & Lomb are:

15	for bacterial protease:	200
	papain, ficin, bromelin:	277
	pancreatin:	164

20  $\alpha$ -Amylase:

A 4% solution of starch is subjected to the action of the enzyme at pH 5.4 and at a temperature of 40°C. The degradation of the starch to dextrin is observed by estimating the colour formed with iodine as a function of time. The end-point has been reached when the colour of the solution is equal to a Hellige Standard colour No. 620 S-5.

30 (Hellige Comparator colour standards are available from Hellige Inc., Stewart Avenue, Garden City, L.I., New York, U.S.A.).

$$35 \quad \text{Activity} = \frac{100.30}{wt} \quad \text{modified Wohlgemuth}$$

units/g, wherein w stands for the weighed amount of enzymes in mg and t stands for 40 the time needed for reaching the end-point of the process.

Malt and fungal amylase (saccharifying enzyme):

45 The determination of the diastase activity by the Windisch-Kolbach method has been described in Analytica-EBC, 2nd edition (Elsevier Publ. Comp. 1963), page 24.

50 Amyloglucosidase (succharifying enzyme):

The determination of the activity is based on the conversion of starch into glucose and the amount of glucose formed is determined by the Luff-Schoorl method. A 4% solution 55 of starch is subjected to the action of the enzyme at pH 4.2 for 60 minutes at 60°C. An amyloglucosidase unit is the amount of enzyme which produces 1 g of glucose under the above-mentioned standard conditions.

60 When the desired degree of saccharification has been attained, the action of the enzymes is stopped by inactivating them by heating the mash to a temperature of from 85 to 115°C. The higher the temperature, 65 the shorter the heating period required.

Generally, the mash is heated for from 5 to 30 minutes. The temperature and time required for inactivating depend on all the enzymes used, but mainly on the  $\alpha$ -amylase derived from *Bacillus subtilis*.

70 The mash still contains undissolved constituents, which are removed by filtration. Any filtering apparatus available may be used for the purpose and the filter cake is thoroughly washed with water. The washing-water passing through the filter is collected separately and is not admixed with the filtrate, because otherwise the filtrate would be diluted again. The washing-water may be efficiently used for making the next mash.

75 The filtrate can now be evaporated into a concentrate or dried into a powder. During the concentrating and drying process, the conditions of temperature are adjusted with the rate of supply of the filtrate to such an extent that the product after dilution or dissolving, respectively, does not deviate from the original filtrate as far as colour and clarity are concerned, and that the saccharides, polysaccharides, proteins and 90 nitrogen containing substances remain dissolved in the water.

80 When the concentration and drying process is carried out at temperatures that are too high, the so-called Maillard reaction occurs due to sugars reacting with proteins. Discoloration due to caramelization of the sugars also occurs. In such cases the final product is no longer completely water soluble.

85 An efficient evaporation of the filtrate to a concentrate may be accomplished in a vacuum film evaporator, such as a falling film evaporator, a Luwa (Trade Mark), Sambay, Sako or Centritherm film evaporator. With this it is possible to evaporate a filtrate having a solids content of about 25% by weight into a concentrate having a solids content of about 80% by weight. The drying 105 into a powder is efficiently carried out in an spray drier. When preparing a dried product (which may be carried out in a conventional type of spray drier) the temperature of the air at the inlet is preferably from 120 to 130°C and that of the air at the outlet 115 from 75 to 85°C.

90 Before the filtrate is either concentrated or dried, bitter substances, such as hop extracts, may optionally be added.

In order that the invention may be more 120 fully understood, the manufacture of a brewers' wort in a concentrated or dried form and which may be carried out continuously will be described, by way of illustration, with reference to the accompanying 125 drawing, which illustrates an apparatus in which the process of the invention may be carried out.

With reference to the drawing, a stream of water 2 and a stream of cereal flour 3 130

are continuously supplied to a continuous flow stirred tank reactor 1 in such a ratio that the solids content of the mash to be formed by mixing the streams in the reactor amounts to 25-50% by weight. A stream 4 of an aqueous solution of the degrading enzymes necessary for the process, (cellulase, hemicellulase, protease,  $\alpha$ -amylase and optionally pectinase) is also continuously supplied to reactor 1. An automatic pH controller 5, connected with the reactor 1, keeps the pH of the mash to the desired value, from pH 4 to 7. The mash then flows through a heat exchanger 6 wherein it is heated to the optimal temperature at which the degrading enzymes display their activity. Subsequently, it flows into the degradation reactor 7, which has been divided into compartments. By a careful choice of the number of compartments the mash has to pass through, the residence time of the mash in the degradation reactor may be regulated accordingly. The temperature is kept at the desired value by a heating element which is thermostatically controlled. The mash passing out of the degradation reactor 7 enters a liquefying convertor 8. This may be a conventional convertor used for hydrolyzing starch, as has been described, for example, in Process Biochemistry, April, 1966, 49-52, or another convertor suitable for the liquefaction of starch. The convertor 8 is also provided with means for controlling the temperature and residence time of the mash therein. After being liquefied, the mash is cooled in a heat exchanger 9 to a temperature of from 55 to 62°C and is subsequently passed to a saccharification reactor 10. This reactor is arranged in the same way as the reactor 7, so that in the reactor 10 the temperature and residence time of the mash may also be controlled. The reactor 10 is continuously supplied with a stream 11 of a solution of a saccharifying enzyme from a storage tank. After saccharification, the mash is heated in a heat exchanger 12 to a temperature which inactivates the enzymes. The heat exchanger 12 has been arranged in such a way that the residence time of the mash therein may be controlled. When the enzymes have been inactivated, the mash is filtered on a continuously operating rotating, vacuum filter 13 or press filter.

The filter cake is continuously washed by a stream of water 14 and the washed filter cake is continuously removed at 15. The water passed through the cake is fed back to the reactor 1 through a pipe 16 and the filtrate is passed to a buffer vessel 18 through a pipe 17. A continuous stream 19 of a solution of bitter substances may be added to the filtrate, if desired. From the buffer vessel, the filtrate is passed through a pipe 20 to a continuously operating spray drier 21, or through a pipe 23 to a con-

tinuously operating vacuum evaporating apparatus 24. A stream of dried product 22 continuously flows from the bottom of the spray drier 21, and a continuous stream of concentrate 25 flows from the evaporating apparatus 24.

For the manufacture of beer or a similar alcoholic beverage from a concentrate or dried product manufactured according to the invention, either the concentrate is diluted with water, or the dried product is dissolved in water to the usual concentration of wort to be fermented. The wort prepared in this way is subjected to the usual main fermentation and after-fermentation, the beverage is lagged and then packed as desired, for example, in bottles, barrels, or cans. If the concentrate or the dried product does not contain bitter adjuncts, then these may be added before, during or after the main fermentation.

Owing to the fermentation, beer or a similar alcoholic beverage is obtained, depending on the raw amylose material chosen to prepare the wort. The taste of the beverage obtained by fermentation may differ to a greater or lesser extent from that of beer depending on the starting materials used. Using barley as the main raw material, a beverage is obtained which in all respects resembles beer manufactured by conventional means.

The fermentation of the brewers' wort obtained according to the invention may be carried out continuously very simply. For this purpose, a mixing vessel is supplied with a continuous stream of the concentrate or dried product prepared according to the invention, and a continuous stream of water in such a ratio that the concentration obtained is the one required for wort. The wort thus prepared is continuously fermented in a known manner. Bitter adjuncts may be added continuously, if desired, during or after the main fermentation step.

A wort obtained by dilution of a concentrate or by dissolving a dried product according to the invention, may serve very well as a so-called "adjunct" in the conventional manufacture of beer. The output capacity in the manufacture of beer is determined, inter alia, by the capacity of the cooker. By the additional use of a concentrate or dried brewers' wort produced according to the invention it is possible to enlarge the fermentation capacity without extending the cooker facilities.

The invention will be more fully understood by the following Examples, given by way of illustration only.

*Example I.*

9 kg of barley (moisture content 13.4% by weight, protein content 9.7% by weight) were ground into flour and stirred into 16 l

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of water having a temperature of 45°C to form a mash. The pH was 5.8, which is a suitable value for enzymatic degradation. 1 g of a cellulase preparation, 1 g of hemi-cellulase preparation, 9 g of a bacterial protease preparation and 9 g of an  $\alpha$ -amylase bacterial preparation were then added to the mash.

The temperature of the now liquefied mash was raised to 50°C with stirring and this temperature was maintained for another 2 hours.

The temperature was then adjusted to 87°C in 15 minutes and the mash was held at this temperature for 30 minutes.

Subsequently, the temperature of the mash was lowered to 60°C by indirect cooling and 1 kg of malt flour (moisture content 9% by weight, diastase activity, according to the Windisch-Kolbach method, 250) was added. The mash was then stirred for another 45 minutes at 60°C. The colour reaction with iodine was then negative and the apparent attenuation was 80%.

Then the mash was heated to boiling point in 25 minutes, and boiled for another 15 minutes. Then it was cooled to 75°C.

The mash was allowed to stand for half an hour without stirring to allow the undissolved constituents to settle, and then the mash was filtered. The filtrate was dried in an "Anhydro" spray drier, the temperature of the air at the inlet being 125°C and the temperature of the air at the outlet being 80°C. 6990 g of a dried product were obtained, the analysis of which was:

moisture content	: 3.7% by weight
extract content	: 93.2% by weight
protein content	: 4.3% by weight.

By "extract content" is meant the amount of dry substance, based on the measuring of the specific gravity of a solution and conversion into percentage of sugar according to Plato's sugar table. The result of a dry product is converted to the solids content. The product was fully water soluble.

3 kg of the dry product were dissolved in 23 l of water and the wort thus prepared had the following analysis:

extract content	: 12.5% by weight
total nitrogen content	: 869 mg/l
$\alpha$ -amino acid content	: 222 mg/l
colour (according to Analytica EBC, 2nd edit., page 20)	: 11.5
pH	: 5.5
apparent attenuation	: 80 %

The wort was fermented at 8°C and the fermentation progressed quickly. After 7 days an apparent extract content of 3.8% by weight had been obtained, so that the wort was filled into a barrel of 25 l for the after-fermentation. An amount of powdered sodium isohumulate dissolved in 1 l of water was added to the barrel, the amount corresponding to 30 mg of isohumulone. After a lagering period of 4 weeks, the beer was drawn off.

The analysis of the brew was as follows:

apparent extract content	2.5 % by weight	80
colour	7.8	
pH	4.5	
viscosity in centi-stokes	1.52	85
foam duration in seconds	329	
foam adhesion	65 %	
turbidity test (according to Analytica EBC, 2nd edit., page 65-66)		90
after 5 days' storage at 40°C and then 24 hours at 0°C	0.7	95
after 7 days' storage at 40°C and then 24 hours at 0°C	0.7	
alcohol content	3.8 % by weight.	100

These analytical results show that the beer is of good quality. The organoleptic properties of the beer were also very good indeed. 105

#### Example II.

A liquefied mash was prepared in the same way as in Example I.

The liquefied mash was cooled to 60°C by indirect cooling and 18 g of an enzyme preparation were added, consisting of amyloglucosidase and  $\alpha$ -amylase derived from fungi. The mash was held at 60°C for 6 hours, subsequently the temperature was raised to the boiling point in the course of 25 minutes and the mash was held at this temperature for 15 minutes. Then the temperature was lowered to 75°C. The mash was allowed to stand for half an hour without being stirred to allow a sediment to be formed, subsequently it was filtered. The filtrate was dried in an "Anhydro" spray drier, the air at the inlet having a temperature of 125°C and the air at the outlet having a temperature of 80°C. 6200 g of the dried product obtained, having the following analysis:

moisture content	: 4.2% by weight	130
extract content	: 94.1% by weight	
protein content	: 3.9% by weight	

The product was completely water soluble. 3 kg of the dried product were then dissolved in 23 l of water and the resulting wort had the following analysis:

5	extract content	11.3% by weight
	total nitrogen content	793 mg/l
10	$\alpha$ -amino acid content	204 mg/l
	colour	9.7
	pH	5.6
15	apparent attenuation	82 %

15 The wort was fermented at 8°C. After 8 days the new beer was filled into a barrel of 25 l capacity for the after-fermentation. An amount of powdered sodium isohumulate dissolved in 1 l of water was also added to the barrel, the amount corresponding to 30 mg of isohumulone. After a lagering period of 3 weeks, the beer was drawn off. The brew had the following analysis:

25	apparent extract content	2.0 % by weight
	colour	5.2
30	viscosity in centistokes	1.50
	foam duration in seconds	343
	foam adhesion	57 %.

35 The apparent extract content is lower than the real one because the alcohol present lowers the specific gravity.

40 The organoleptic properties of the beer were quite satisfactory.

#### Example III.

The process described in Example I was carried out as far as the filtering of the 45 boiled and cooled mash. The resulting filtrate was evaporated in one step in a film evaporator (Sambay type) under reduced pressure at 40 mm mercury, absolute, to a solids content of 80% by weight. The resulting concentrate was a thick, fluid, but easy 50 to handle, syrup 8352 g of concentrate were obtained. 2000 g of the concentrate were dissolved in 14.8 l of water and the resulting wort had the following analysis:

55	extract content	12 % by weight
	total nitrogen content	920 mg/l
60	$\alpha$ -amino acid content	238 mg/l
	colour	11.2
	pH	5.5
65	apparent attenuation	80.5%

These analytical values show that this wort is a useful starting material for the manufacture of beer.

#### Example IV

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10 kg of mechanically degerned corn grits were ground into flour. The flour was stirred into a mash with 20 l of water having a temperature of 40°C. 1 g of a cellulase-hemicellulase preparation, 10 g of a protease 75 preparation from bacteria and 10 g of an  $\alpha$ -amylase preparation were then added to the mash.

The mash was heated to 50°C and held at this temperature for 3 hours and was then 80 heated to 88°C in the course of 15 minutes and held at this temperature for 40 minutes.

After the temperature of the mash had been lowered to 60°C by indirect cooling, 1000 g of malt flour and 5 g of a fungal 85  $\alpha$ -amylase preparation were added. The temperature was held at 60°C for 2 hours. The mash was then boiled for 20 minutes.

The warm mash was filtered and the filtrate was dried in a spray drier in the manner described in Example I. 90 7020 g of a dried product having the following analysis were obtained:

moisture content	4.5% by weight	95
extract content	94.2% by weight	
protein content	4.4% by weight	
apparent attenuation	72 %	

The dried product proved to be highly suitable for use as an adjunct in conventional malt beer manufacture. 100

#### WHAT WE CLAIM IS:—

1. A process for the manufacture of a 105 brewers' wort in a concentrated or dried form, which comprises the steps of:

(a) mixing a finely-divided starch-containing material with water, at a temperature of from 30 to 50°C, to form a mash 110 having a solids content of from 25 to 50% by weight,

(b) adding cellulase, hemicellulase, protease and  $\alpha$ -amylase to the mash and, if necessary, adjusting the pH of the mash to 115 between 4 and 7,

(c) raising the temperature of the mash to from 50 to 60°C so as to degrade and dissolve the cellulose, hemicellulose and proteins in the mash,

(d) further raising the temperature of the mash to from 86 to 88°C so as to liquefy the starch constituents of the mash,

(e) cooling the mash to from 55 to 62°C, adding a saccharifying enzyme, and saccharifying the starch until the ratio of fermentable sugars to non-fermentable polysaccharides in the mash reaches a proportion suitable for the brewers' wort,

(f) raising the temperature of the mash 130

- to from 85 to 115°C so as to inactivate the saccharifying enzymes,
- (g) filtering the mash, and
- (h) concentrating or drying the filtrate.
- 5 2. A process according to claim 1, in which, additionally, pectinase is added to the mash in step (b).
3. A process according to claim 1 or 2, in which the starch-containing material is a 10 cereal.
4. A process according to claim 3, in which the cereal is barley.
5. The process according to any of claims 1 to 4 in which the mash is held at a temperature of from 50 to 60°C for from  $\frac{1}{2}$  to 15 4 hours in step (c).
6. A process according to any of claims 1 to 5, in which the mash is held at a temperature of from 86 to 88°C for from 10 to 20 60 minutes in step (d).
7. A process according to any of claims 1 to 6, in which the mash is held at a temperature of from 55 to 62°C for from  $\frac{1}{2}$  to 25 10 hours in step (e), after the saccharifying enzyme has been added to the mash.
8. A process according to any of claims 1 to 7, in which the mash is heated to a temperature of from 85 to 115°C for from 5 to 30 30 minutes in step (f).
9. A process according to any of claims 1 to 8, in which 200-600 units of cellulase, 35 200-1000 units of hemicellulase, 50-500 Northrop units of protease, 175,000-1,000,000 modified Wohlgemuth units of  $\alpha$ -amylase are added to the mash in step (b), per one Kg. of solids in the mash.
10. A process according to claim 9, in which from 500 to 2000 units of pectinase are added to the mash in step (b), per one 40 Kg. of solids in the mash.
11. A process according to any of claims 1 to 10, in which the saccharifying enzyme is malt, malt extract and/or a fungal amylase preparation, has a diastase activity of 45 250 when measured by the Windisch-Kolbach technique and is added to the mash in an amount of about 10% by weight of the starch-containing material, and/or is an amyloglucosidase preparation added to the 50 mash in an amount to give from 100 to 300 amyloglucosidase units per Kg. of starch-containing material.
12. A process according to any of claims 1 to 11, in which the filter cake obtained in step (g) is washed and the washing-water used to prepare the mash in step (a) of the process. 55
13. A process according to any of claims 1 to 12, in which the filtrate obtained in step (g) is evaporated in a vacuum film evaporator to a solids content of about 80% by weight. 60
14. A process according to any of claims 1 to 12, in which the filtrate obtained in step (g) is dried in a spray drier. 65
15. A process according to claim 14, in which the drying is carried out at an inlet air temperature of from 120 to 130°C and an outlet air temperature of from 75 to 85°C in the spray drier. 70
16. A process according to any of claims 1 to 15, when carried out continuously.
17. A process according to any of claims 1 to 16, which comprises adding bitter adjuncts to the filtrate obtained in step (g), before concentration or drying of the filtrate. 75
18. A process for the manufacture of a brewers' wort in a concentrated or dried form substantially as herein described with reference to the accompanying drawing. 80
19. A process for the manufacture of a brewers' wort in a concentrated or dried form substantially as herein described in any of the Examples.
20. A brewers' wort when prepared by the process claimed in any of claims 1 to 19. 85
21. A process for the manufacture of beer, or similar alcoholic beverage, which comprises fermenting the brewers' wort claimed in claim 20. 90
22. A process according to claim 21, when carried out continuously.
23. Beer, or similar alcoholic beverage, when prepared by the process claimed in claim 21 or 22. 95

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1,248,505

COMPLETE SPECIFICATION

1 SHEET

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